Space Weather Technical Forecast

Issued on Sunday, 13 March 2022 at 13:10 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrival on 13th with G1/Minor geomagnetic storms expected and a Chance of G2/Moderate storm on Days 1 and 2 (13-14 Mar). Reducing Chance of further M-Class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with a few C-class flares observed. Peak flare was a C5 from the plage area in the northwest, near ex-AR2962. There are five sunspot regions on the disc. The largest of these AR2965 Fai/Beta has shown some slight development but remains relatively stable, with the other large region AR2964 Cho/Beta showing little sign of flare activity. AR2960 Dso/Beta is rotating off the Earth-side of the disc in the next 12 hours, while AR2967 Hsx/alpha and AR2968 Axx/alpha are both simple regions. There have been no Earth-directed CMEs in the last 24 hours

Solar Wind / Geomagnetic Activity: Background solar wind speeds, observed by DSCOVR and ACE at L1, become elevated with the arrival of a CME at 13/1014 UTC. with solar winds peaking at 560km/s, and the density rising from below average levels to above average at 23-38ppcc. This was accompanied by the weak magnetic field becoming strong, peaking 20nT. Although initially positive (northward) in the Bz direction, peaking +18nT, this soon rotated to negative (southward) to be at -9nT. Phi angle was initially negative (towards the Sun) but rotated briefly to positive with the CME arrival. Geomagnetic activity was initially quiet (Kp 0-2), but was Active (Kp4) 13/0900-1200 UTC

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at background levels throughout. The high energy electron flux (greater than 2 MeV) was at background levels, with the corresponding 24-hour integrated electron fluence below the Active (1e8 integrated pfu) threshold. Observed fluence at 13/0000 UTC was 1.2e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly Low, perhaps Moderate, with a chance of M-class flares. The risk of M-flares mainly comes from AR2965 and AR2964, with the risk reducing slightly through Day 2 (14th) as AR2964 rotates off the disc.

Solar Wind / Geomagnetic Activity: Ongoing CME effects are expected day 1(13th) and likely early day 2 (14th), with G1/Minor Geomagnetic Storms expected and a chance of G2/Moderate geomagnetic storms. Once Earth exits the trailing portion of the CME day 2 (14th), solar winds are expected to gradually ease to background levels, with no further enhancements expected. Geomagnetic activity will then gradually return to largely Quiet with isolated Unsettled intervals Days 3 and 4 (15th and 16th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at background levels. The high energy (greater than 2 MeV) electron flux is currently at background levels. An increase in electron flux is likely as CME effects wane through Days 3 and 4 (15-16th), perhaps reaching High levels at diurnal peak. The corresponding fluence is expected to be below the Active threshold (1e8 integrated pfu) through

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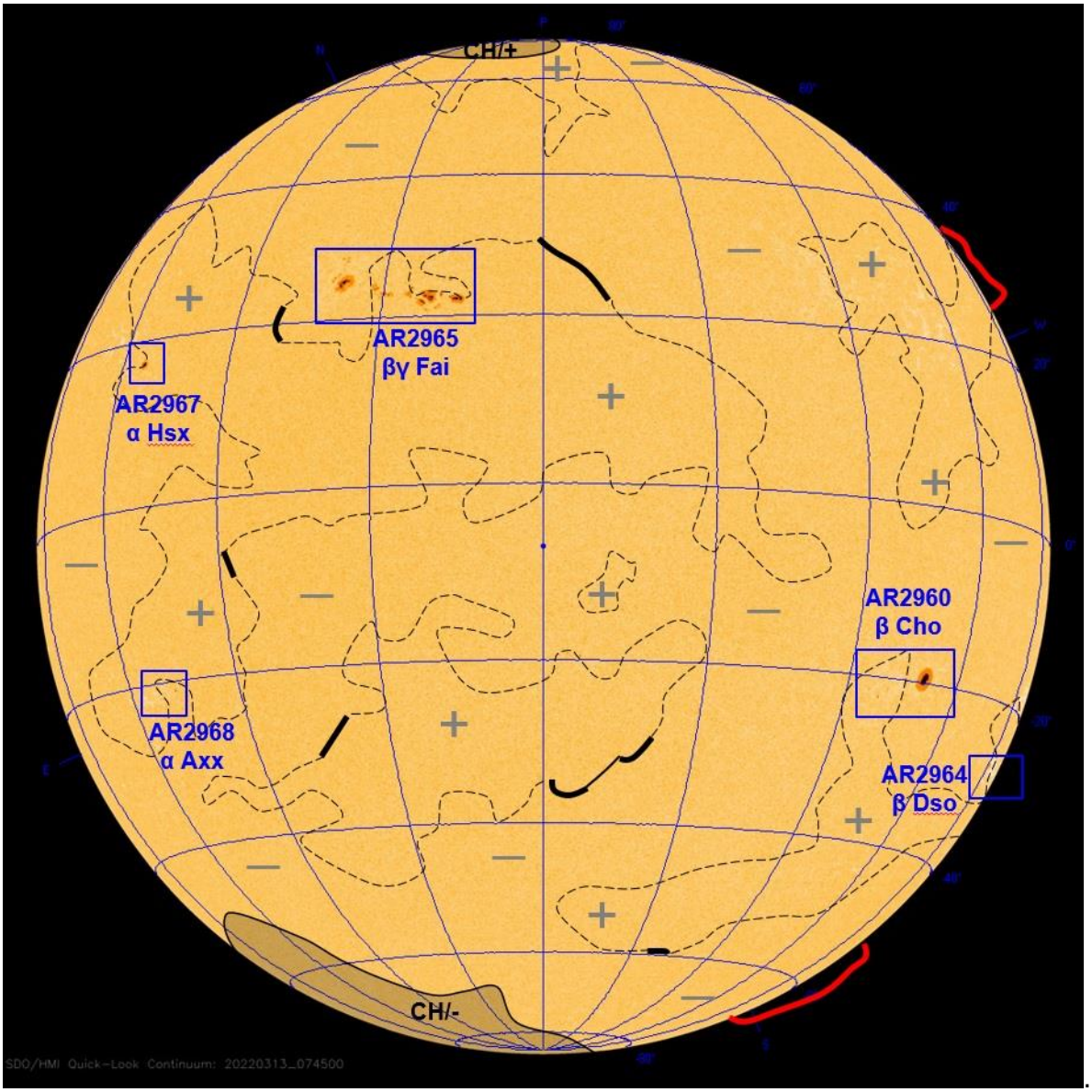
much of this period, with an increase possible through Days 3 and 4 (15th and 16th).

Figure 1. Solar Analysis Valid 13/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME arrival recently occurred, with impact at L1 at 13/1014 UTC. This was likely the arrival of the large Halo CME from the long duration C-class flare from ex-AR2962 on the 10th, but perhaps incorporates some element from a filament eruption on the 9th March.

Solar winds are currently elevated, at around 500-600km/s, and whilst initial geomagnetic activity has been fairly subdued, the arrival of the CME's anticipated magnetic flux rope could bring an extended period of negative (southward) pointing field later day 1 and into day 2 (13th and 14th). Once the CME completes its passing day 2, solar winds are expected to only gradually ease towards background through the rest of the period.

Geomagnetic activity is currently Unsettled to Active, but likely increasing to G1/Minor Storm as the magnetic flux rope moves through later day 1 and into day 2 (13th and 14th). There is a chance of isolated G2/Moderate storms. Activity easing through the 14th becoming mostly Quiet with isolated unsettled spells by day 3 and 4 (15th and 16th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	60	1	1
Strong	G3	No	10	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial Halo	Filament Eruption	36E 18S	445	13/2300UTC	Likely miss, but could glance.
11/0406	Halo	C5-flare and filament	11W 23N	577	13/2200UTC	Arrived 13/1014 UTC. Could have included above CME.

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Figure 2: L1 Observed Solar wind parameters, with clear CME arrival

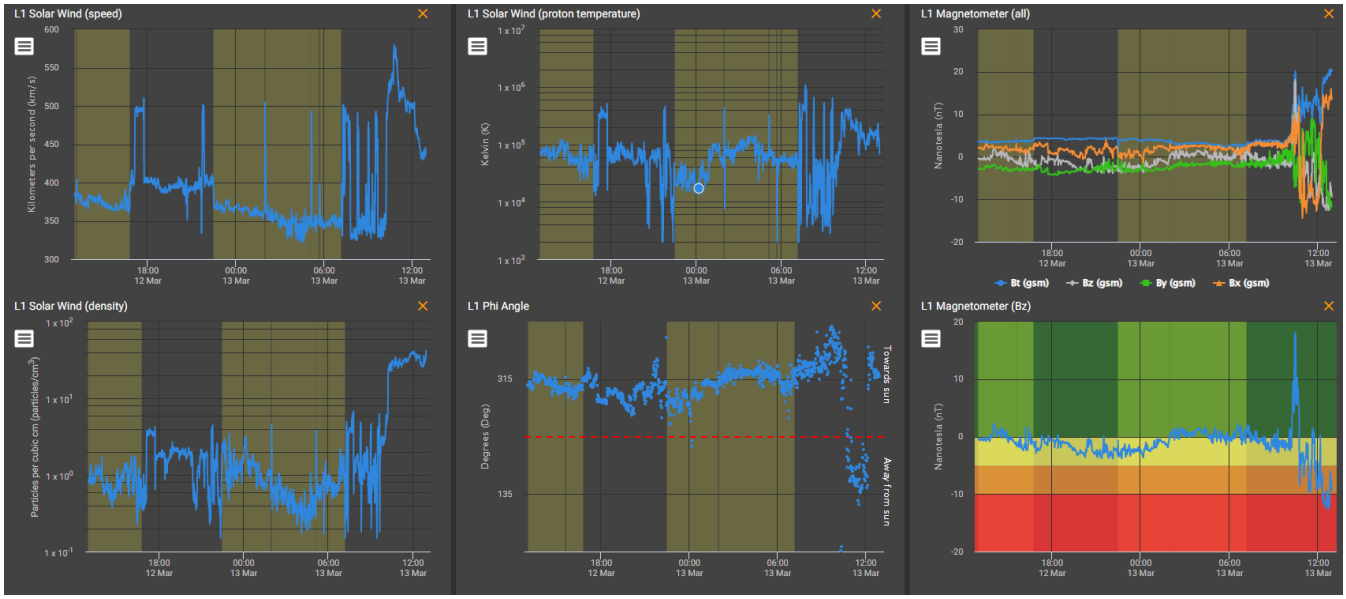
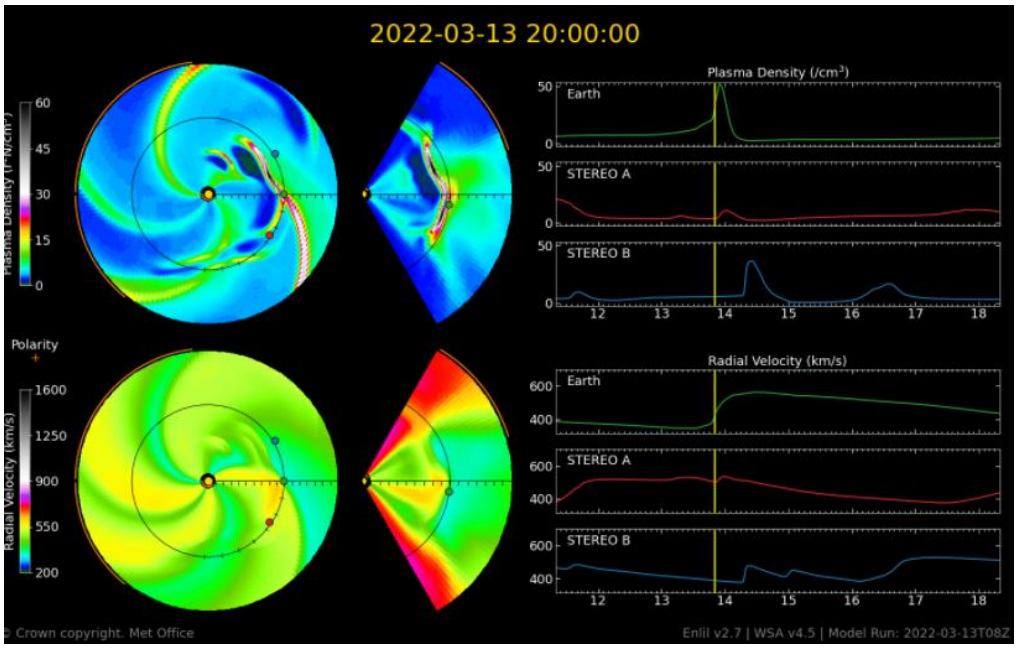
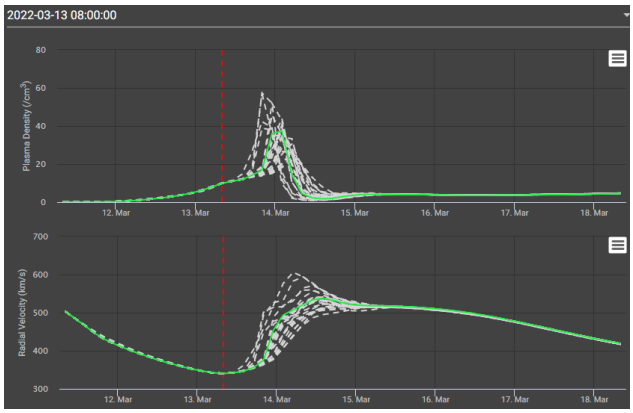


Figure 3: Enlil forecast for CME arrival and Ensemble





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Radio Blackouts - X-Ray Flares:

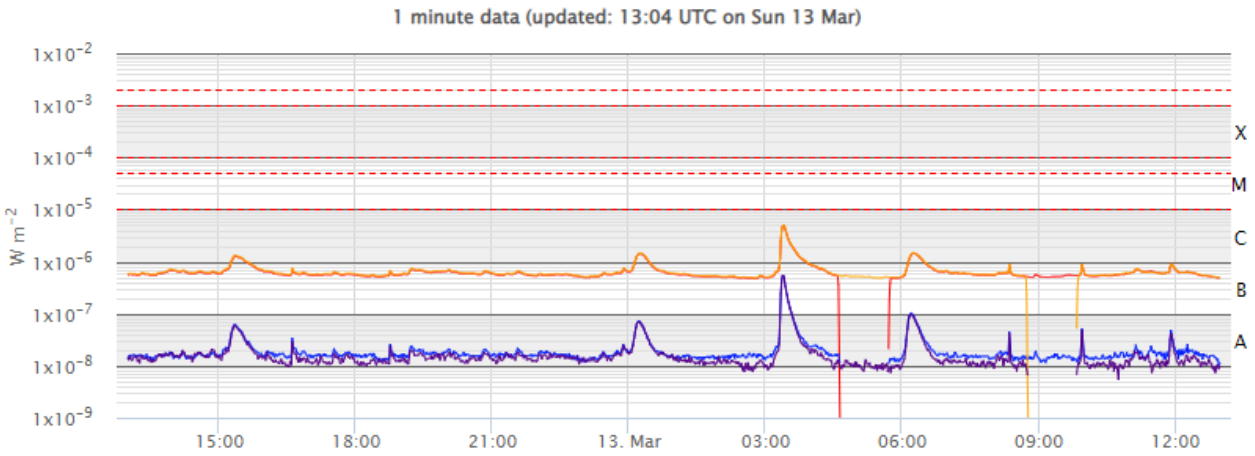
There are currently five sunspot regions on the visible disc, with Low solar activity. The largest flare, a C5 at 13/0323UTC originated from the plage region in the northwest, near to the location of ex-AR2962.

The largest and most prominent region is AR2965, Fai/Beta-gamma in the northeast which has continued to show development of immature penumbra amongst its intermediate spots, but activity remains fairly muted. Likewise, AR2960, the large Cho/Beta spot in the southwest has remained stable, with no flare activity observed. AR2964 Dso/Beta is now rotating off the disc, and was the source of an M2-flare on the 12th, whilst impossible to accurately assess, further flaring from this region is possible for the next 24 hours, as it rotates around the limb. AR2968 Axx/alpha in the southeast is a small unipolar spot, but was the source of C1-flare 13/0615 UTC, although no further development has since occurred. The final spot is a small Hsx/alpha region in the northeast.

Activity is forecast to remain Low with further C-flares expected, and a chance of increasing to Moderate from any M-flares, with the main risk from AR2965, and potentially AR2960 as it rotates off the limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	20	15	15
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 4: GOES-16/17 X-ray Flux



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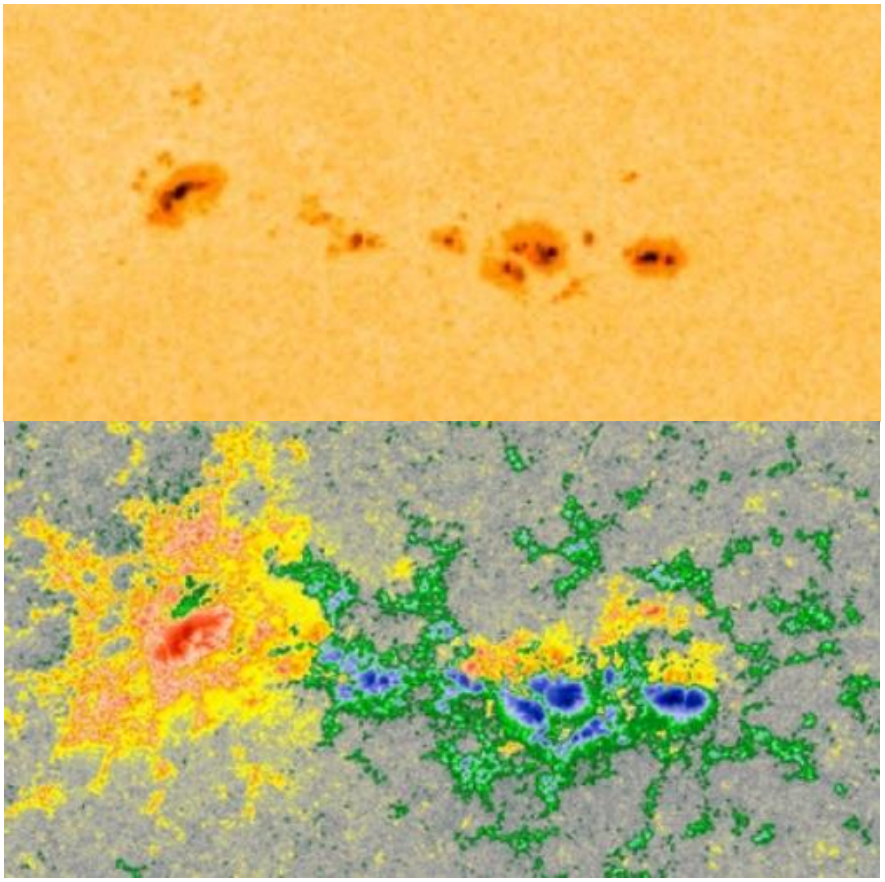
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 has returned to background levels after a slight rise due to the long period C-class flare from a plage region in the northwest on 10 March There is just a very slight chance of an S1/Minor radiation storm, should any further flares occur from this plage region, or from any of the larger regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: SDO HMI Intensitygram and Magnetogram of large sunspot AR2965



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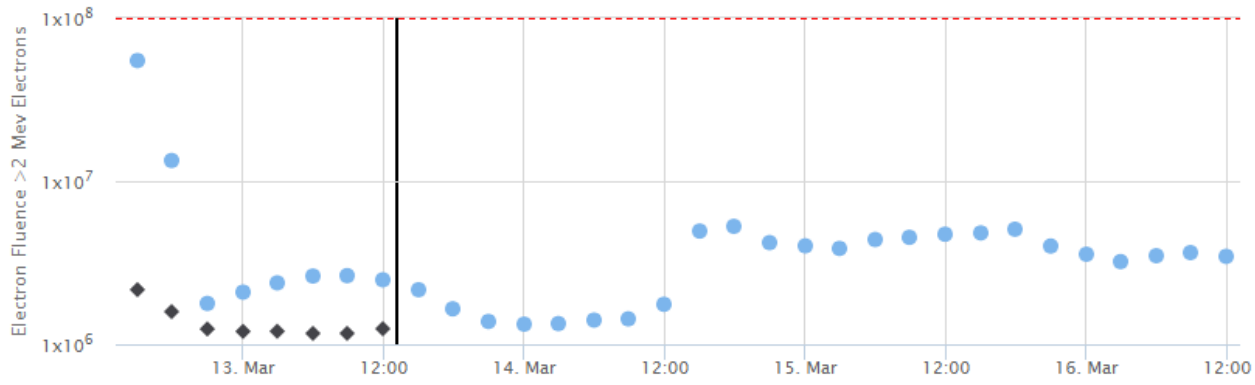
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed at GEO by GOES-16, is currently at background levels. Recent CME arrival has the potential to elevate electron numbers, with the potential for moderate to high flux developing day 2 (14th), once any geomagnetic activity subsides. Elevated solar winds are then expected to gradually ease, with no other notable enhancements currently forecast.

The associated 24 hour electron fluence is expected to remain below the Active threshold, but with a slight chance of rising above day 3 and day 4 (15th and 16th) due to any enhancement from the CME arrival on the 13th. REFM is giving good guidance at first, but will not take account of the recent CME arrival, with poor guidance likely from the 14th onward.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	1	20	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: GOES-16 >2MeV Electron fluence and REFM



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